The Delphion Integrated View

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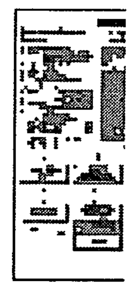

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Abstract:

PROBLEM TO BE SOLVED: To obtain a magnetic recording medium and a magnetic storage device having enhanced heat stability of written bits and reduced medium noise and capable of executing high density recording having high reliability without exerting adverse influence on performance of the magnetic recording medium and enhancing recording resolution particularly by enhancing an intra-surface orientation property of a magnetic layer.

SOLUTION: This magnetic recording medium is provided with at least one exchanged layer structure and a magnetic layer 22 provided thereon. The exchanged layer structure consists of a ferromagnetic layer 20 and a non-magnetic joining layer 21 provided on an upper surface of the ferromagnetic layer 20 and on a lower surface of the magnetic layer 22. Magnetization directions of the ferromagnetic layer 20 and the magnetic layer 22 are anti-parallel to each other. The non-magnetic joining layer 21 consists of a so called Ru-M3 alloy into which an element or an alloy M3 is added to adjust lattice misfit of the non-magnetic joining layer 21 to the magnetic layer 22 and the ferromagnetic layer 20 positioned in an upper and lower direction respectively to be about 6% or below.

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CLAIMS

[Claim(s)]
[Claim 1] It is the magnetic-recording medium which is equipped with the following, and the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually, and this nonmagnetic binder course consists of an alloy with which the element or the alloy M3 was added, and which becomes Ru-M3, and is characterized by addition of M3 adjusting the grid mismatching of this nonmagnetic binder course, this magnetic layer of the upper and lower sides, and this ferromagnetic layer to about 6% or less. At least one exchange layer structure. Having the magnetic layer prepared on this exchange layer structure, this exchange layer structure is a ferromagnetic layer. The nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer.
[Claim 2] It has the following, the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually, and this nonmagnetic binder course is a magnetic-recording medium which consists of a becoming alloy and is characterized by the bird clapper from M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys Ru-M3. At least one exchange layer structure. Having the magnetic layer prepared on this exchange layer structure, this exchange layer structure is a ferromagnetic layer. The nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer.
[Claim 3] The addition to Ru of the becoming element is a magnetic-recording medium according to claim 2 characterized by being selected [in Co / in less than / 50at% / and Cr / in less than / 50at% / and Fe / in the case of less than / 60at% / and nickel] by less than [50at%] in the case of less than [10at%] and Mn aforementioned M3.
[Claim 4] The aforementioned nonmagnetic binder course is a magnetic-recording medium of a claim 1-3 given in any 1 term which has the thickness selected within the limits of 0.4-1.0nm.
[Claim 5] The aforementioned ferromagnetic layer is a magnetic-recording medium of a claim 1-4 given in any 1 term which it consists of material chosen from the group which consists of Co, nickel, Fe, nickel system alloy, Fe system alloy and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M2, and is M2=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.
[Claim 6] The aforementioned magnetic layer is a magnetic-recording medium of a claim 1-5 given in any 1 term which it consists of material chosen from the group which consists of Co and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M4, and is M4=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.
[Claim 7] Magnetic storage equipped with at least one magnetic-recording medium of a claim 1-6 given in any 1 term.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the magnetic-recording medium and magnetic storage which started a magnetic-recording medium and magnetic storage, especially were suitable for high-density record.
[0002]
[Description of the Prior Art] The recording density of level magnetic-recording media, such as a magnetic disk, increased remarkably by development of reduction of a medium noise, a magnetoresistance-effect type head, and a spin valve head. A typical magnetic-recording medium has the structure where the laminating of a substrate, a ground layer, a magnetic layer, and the protective layer was carried out in this sequence. A ground layer consists of Cr or a Cr system alloy, and a magnetic layer consists of a Co system alloy.
[0003] The various proposals of the method of reducing a medium noise are made until now. For example, Okamoto et al., "Rigid Disk Medium For 5Gbit/in2 Recording", AB-3, Intermag '96 Decreasing the grain size and the size distribution of a magnetic layer is proposed by Digest by decreasing the thickness of a magnetic layer using the suitable ground layer which consists of CrMo. Moreover, in U.S. Pat. No. 5,693,426, using the ground layer which consists of NiAl is proposed. Furthermore, Hosoe et al. "Experimental Study of Thermal Decay inHigh-Density Magnetic Recording Media" IEEE Trans. Magn. Vol.33 In 1528 (1997), using the ground layer which consists of CrTi is proposed. The orientation within a field of a magnetic layer is urged to the ground layer like the above, and it makes the thermal stability of residual magnetization and a bit increase. Decreasing the thickness of a magnetic layer, making resolution high or decreasing the changes width of face between the written-in bits is also proposed. Furthermore, Cr segregation of the magnetic layer which consists of a CoCr system alloy is promoted, and decreasing the switched connection between particles is also proposed.
[0004] However, the written-in bit becomes instability according to the demagnetizing field and thermal activation which increase according to linear density as the particle of a magnetic layer becomes small and is isolated magnetic more mutually. Lu et al. "Thermal Instability at 10 Gbit/in2 Magnetic Recording" IEEE Trans. Magn. Vol.30 In 4230 (1994) By the medium which had the switched connection of each particle of the ratio which a diameter becomes Ku V/kB T-60 in a 400kfci bit by 10nm suppressed by the micro magnetic simulation, it is announced that it is easy to receive large thermal decay. Here, it is Ku. The constant of a magnetic anisotropy and V are the balancer product of a magnetic particle, and kB. A Boltzmann's constant and T show temperature. In addition, the ratio which becomes Ku V/kB T is also called thermal stability coefficient.
[0005] Abarra et al. "Thermal Stability of Narrow Track Bits in a 5 Gbit/in2Medium" IEEE Trans. Magn. In Vol.33 and 2995 (1997) It is 5Gbit/in2 to stabilize the bit in which existence of the exchange interaction between particles was written. It is reported by the MFM (force microscope between MAG) analysis of the 200kfci bit which annealed the CoCrPtTa/CrMo medium. However, 20Gbit/in2 In the

above recording density, suppression of the magnetic combination between the further particles becomes indispensable.
[0006] The proper solution over this was making the magnetic anisotropy of a magnetic layer increase. However, in order to make the magnetic anisotropy of a magnetic layer increase, a big load will be applied to the write-in magnetic field of a head.
[0007] Thermally moreover, the coercive force of an unstable magnetic-recording medium helium et al., "High Speed Switching in Magnetic Recording Media" J. Magn. Magn. Mater. Vol.155 In 6 (1996) About a magnetic tape medium J. H. Richter "Dynamic Coercivity Effects in Thin Film Media" IEEE Trans.Magn. Vol.34 In 1540 (1997) According to reduction of switch time, it increases rapidly as the magnetic-disk medium is reported. For this reason, a bad influence will arise at data speed. That is, the magnetic field strength of a head required to be able to write data in a magnetic layer how much quickly, or reverse magnetization of a magnetic particle increases rapidly according to reduction of switch time.
[0008] On the other hand, the method to which the rate of orientation of a magnetic layer is made to increase is also proposed by performing suitable texture processing for the substrate under a magnetic layer as other methods of raising thermal stability. For example, Akimoto under issue et al. "MagneticRelaxation in Thin Film Media as a Function of Orientation" J. Magn. Magn. Mater. (1999) It is efficiency Ku V/kB by the micro magnetic simulation. It is reported that a T value increases by the slight increase in the rate of orientation. Consequently, Abarra et al. "TheEffect of Orientation Ratio - the Dynamic Coercivity of Media for >15Gbit/in2 Recording" EB-02 Intermag The time dependency of the coercive force which improves the over-writing performance of a magnetic-recording medium can be weakened more as reported in '99 and Korea.
[0009] Furthermore, the keeper magnetic-recording medium for improving thermal stability is also proposed. A keeper layer consists of a soft-magnetism layer parallel to a magnetic layer. This soft-magnetism layer is arranged on a magnetic layer or in the bottom. In many cases, Cr MAG insulating layer is prepared between a soft-magnetism layer and a magnetic layer. A soft-magnetism layer decreases the demagnetizing field of the bit written in the magnetic layer. However, the purpose of decoupling of the particle of a magnetic layer is no longer attained by combination of a soft-magnetism layer which carries out switched connection to a magnetic-recording layer continuously. Consequently, a medium noise increases.
[0010]
[Problem(s) to be Solved by the Invention] What has various methods of improving thermal stability and reducing a medium noise is proposed. However, by the method proposed, the thermal stability of the written-in bit could not be improved sharply, but, for this reason, decreasing a medium noise sharply had the problem of being difficult. Furthermore, there was also a problem of having a bad influence on the performance of a magnetic-recording medium for the cure for reducing a medium noise depending on the proposal method.
[0011] Specifically, in order to obtain the high magnetic-recording medium of thermal stability, it is (i) magnetic-anisotropy constant Ku. The (ii) temperature T to which it is made to increase is decreased, or the cure of making the particle volume V of a magnetic layer (iii) increase etc. can be considered. However, as a cure (i), coercive force will increase and it will become more difficult to write information in a magnetic layer. On the other hand, considering that operating temperature, such as a disk drive, may exceed 60 degrees C, the cure (ii) is un-practical. Furthermore, a cure (iii) will make a medium noise increase like the above. Moreover, although also making the thickness of a magnetic layer increase is considered instead of a cure (iii), resolution will fall by this method. then -- while being able to perform reliable high-density record, without this invention's improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- it aims at offering the magnetic-recording medium and magnetic storage which resolution can improve
[0012]
[Means for Solving the Problem] The above-mentioned technical problem is equipped with at least one

exchange layer structure and the magnetic layer prepared on this exchange layer structure. this exchange layer structure It consists of a ferromagnetic layer and a nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer, and the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually. this nonmagnetic binder course It consists of an alloy with which the element or the alloy M3 was added and which becomes Ru-M3, and is attained by the magnetic-recording medium characterized by addition of M3 adjusting the grid mismatching of this nonmagnetic binder course, this magnetic layer of the upper and lower sides, and this ferromagnetic layer to about 6% or less. while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium which resolution can improve is realizable

[0013] The above-mentioned technical problem is equipped with at least one exchange layer structure and the magnetic layer prepared on this exchange layer structure. this exchange layer structure It consists of a ferromagnetic layer and a nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer, and the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually. this nonmagnetic binder course It consists of an alloy which becomes Ru-M3 and is attained by the magnetic-recording medium characterized by the bird clapper from M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium which resolution can improve is realizable

[0014] the above M3 -- the addition to Ru of an element -- the case of Co -- 50at(s)% -- in Cr, in less than [50at%] and Fe, it may be hereafter selected [in the case of less than / 60at% / and nickel] by less than [50at%] in the case of less than [10at%] and Mn

[0015] The aforementioned nonmagnetic binder course is good also as composition which has the thickness selected within the limits of 0.4-1.0nm.

[0016] The aforementioned ferromagnetic layer may consist of material chosen from the group which consists of Co, nickel, Fe, nickel system alloy, Fe system alloy and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M2, and may be M2=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.

[0017] The aforementioned magnetic layer may consist of material chosen from the group which consists of Co and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M4, and may be M4=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.

[0018] The magnetic storage equipped with at least one magnetic-recording medium of one of the above-mentioned composition can also attain the above-mentioned technical problem. while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic storage which resolution can improve is realizable

[0019]

[Embodiments of the Invention] Hereafter, the example of this invention is explained with a drawing.

[0020]

[Example] First, the principle of operation of this invention is explained.

[0021] Two or more layers which have the magnetization structure which is anti-parallel mutually are used for this invention. For example S. S.P. Parkin "Systematic Variation of the Strength and Oscillation Period of Indirect Magnetic Exchange Coupling though the 3d 4d and 5d Transition Metals" Phys. Rev. Lett. Vol.67 In 3598 (1991) Magnetic transition metals, such as Co, Fe, nickel, etc. which are combined with a magnetic layer through thin nonmagnetic interlayers, such as Ru and Rh, are explained. On the other hand, the spin bulb which uses the layer like the above as a pinning layer by which the laminating

was carried out is proposed by the U.S. Pat. No. 5,701,223 official report for stabilization of a sensor.
[0022] When Ru or Rh layer prepared between two ferromagnetic layers has specific thickness, the magnetization direction of a ferromagnetic layer can be mutually made parallel or anti-parallel. For example, the effective grain size of a magnetic-recording medium can make it increase in the case of the structure where the magnetization direction consists of two ferromagnetic layers which are anti-parallel by mutually different thickness, without having substantial influence on resolution. Although the signal amplitude reproduced from such a magnetic-recording medium decreases by magnetization of an opposite direction, it can negate the influence by one layer to this by preparing the layer of suitable thickness and the magnetization direction in the bottom of laminating magnetic layer structure further. Consequently, the signal amplitude reproduced from a magnetic-recording medium can be increased, and effective particle volume can be increased. Therefore, the written-in high bit of thermal stability is realizable.
[0023] this invention raises the thermal stability of the written-in bit by carrying out switched connection of the magnetic layer in the magnetization direction contrary to other ferromagnetic layers, or using laminating ferrimagnetism structure. A ferromagnetic layer or laminating ferrimagnetism structure consists of a magnetic layer which consists of a particle exchanged - decoupled. That is, in order that this invention may raise the performance of the thermal stability of a magnetic-recording medium, an exchange pinning ferromagnetism layer or ferrimagnetism multilayer structure is used.
[0024] Drawing 1 is the cross section showing the important section of the 1st example of the magnetic-recording medium which becomes this invention. It has the structure by which the laminating was carried out in this sequence as the nonmagnetic substrate 1, the 1st seed layer 2, the NiP layer 3, the 2nd seed layer 4, the ground layer 5, the nonmagnetic interlayer 6, the ferromagnetic layer 7, the nonmagnetic binder course 8, a magnetic layer 9, a protective layer 10, and a lubricating layer 11 showed a magnetic-recording medium to drawing 1 .
[0025] For example, the nonmagnetic substrate 1 consists of aluminum, an aluminum alloy, or glass. This nonmagnetic substrate 1 does not need to be given even if texture processing is performed. Especially the 1st seed layer 2 consists of NiP, when the nonmagnetic substrate 1 consists of glass. The NiP layer 3 does not need to be given even if texture processing or oxidation treatment is performed. The 2nd seed layer 4 is formed in order to make good orientation of the field (001) of the ground layer 5 at the time of using the alloy of B-2 structures, such as NiAl and FeAl, for the ground layer 5, or (112) a field. The 2nd seed layer 4 consists of the same suitable material as the 1st seed layer 2.
[0026] Along with the hoop direction of a disk, i.e., the direction where the truck on a disk extends, when a magnetic-recording medium is a magnetic disk, texture processing performed to the nonmagnetic substrate 1 or the NiP layer 3 is performed.
[0027] The nonmagnetic interlayer 6 is formed in order to promote the orientation of epitaxial growth of a magnetic layer 9, reduction of particle distribution width of face, and the anisotropy shaft (easy axis) of a magnetic layer 9 along the field parallel to the recording surface of a magnetic-recording medium. This nonmagnetic interlayer 6 consists of an alloy which has hcp structure, such as CoCr-M, and has the thickness selected by the range of 1-5nm. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys.
[0028] The ferromagnetic layer 7 consists of Co, nickel, Fe, Co system alloy, a nickel system alloy, a Fe system alloy, etc. That is, Co system alloy containing CoCrTa, CoCrPt, and CoCrPt-M can be used for the ferromagnetic layer 7. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys. This ferromagnetic layer 7 has the thickness selected by the range of 2-10nm. The nonmagnetic binder course 8 consists of Ru, Rh, Ir, Ru system alloy, a Rh system alloy, an Ir system alloy, etc. For example, this nonmagnetic binder course 8 has the thickness selected by the range of 0.4-1.0nm, and has about 0.6-0.8nm thickness preferably. By selecting the thickness of the nonmagnetic binder course 8 in such a range, the magnetization direction of the ferromagnetic layer 7 and a magnetic layer 9 serves as anti-parallel mutually. The ferromagnetic layer 7 and the nonmagnetic binder course 8 constitute an exchange layer structure.
[0029] A magnetic layer 9 consists of a Co system alloy containing Co or CoCrTa, CoCrPt, and CoCrPt-M etc. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys. A magnetic layer 9 has the thickness

selected by the range of 5-30nm. Of course, a magnetic layer 9 cannot be overemphasized by that you may be the composition which is not limited to the thing of a single layer structure, but consists of multilayer structure.

[0030] A protective layer 10 consists of C. Moreover, a lubricating layer 11 consists of organic substance lubricant for using a magnetic-recording medium with magnetic transducers, such as for example, a spin valve head. A protective layer 10 and a lubricating layer 11 constitute the protective-layer structure on a magnetic-recording medium.

[0031] The layer structure prepared in the bottom of an exchange layer structure is not limited to what is shown in drawing 1 , of course. For example, the ground layer 5 may consist of Cr or a Cr system alloy, and may be formed in the thickness selected on the substrate 1 by the range of 5-40nm, and an exchange layer structure may prepare it on such a ground layer 5.

[0032] Next, the 2nd example of the magnetic-recording medium which becomes this invention is explained.

[0033] Drawing 2 is the cross section showing the important section of the 2nd example of the magnetic-recording medium which becomes this invention. The same sign is given to the same portion as drawing 1 among this drawing, and the explanation is omitted.

[0034] An exchange layer structure consists of two nonmagnetic binder courses 8 which constitute ferrimagnetism multilayer structure, 8-1 and two ferromagnetic layers 7, and 7-1 in the 2nd example of this magnetic-recording medium. Since it negates each other, without two nonmagnetic binder courses 8 and magnetization of 8-1 negating a part of magnetic layer 9 by using such structure, it becomes possible to increase effective magnetization and a signal. Consequently, the particle volume of a magnetic layer 9 and the thermal stability of magnetization increase effectively. As long as the orientation of the easy axis of a record layer is kept desirable, increase of efficiency particle volume can be aimed at according to the two-layer structure which consists of a pair of a ferromagnetic layer and a non-magnetic layer and which is added.

[0035] The ferromagnetic layer 7-1 consists of the same material as the ferromagnetic layer 7, and thickness is also selected by the same range as the ferromagnetic layer 7. Moreover, the nonmagnetic binder course 8-1 consists of the same material as the nonmagnetic binder course 8, and is selected by the range as the nonmagnetic binder course 8 also with the same thickness. Between the ferromagnetic layer 7 and 7-1, c axis meets field inboard substantially and a particle grows pillar-shaped.

[0036] In this example, the magnetic anisotropy of the ferromagnetic layer 7-1 is set up more strongly than the magnetic anisotropy of the ferromagnetic layer 7. Similarly the magnetic anisotropy of the ferromagnetic layer 7-1 may be set up, even if stronger [than the magnetic anisotropy of a magnetic layer 9] and weak. In short, the magnetic anisotropy of the ferromagnetic layer 7 should be just weaker than the layer 9 of the upper and lower sides, and 7-1.

[0037] Moreover, the residual magnetization of the ferromagnetic layer 7 and the product of thickness are set up smaller than the residual magnetization of the ferromagnetic layer 7-1, and the product of thickness.

[0038] Drawing 3 is drawing showing the magnetic properties within a field of the single CoPt layer of 10nm of thickness formed on Si substrate. A vertical axis shows magnetization (emu) among drawing 3 , and a horizontal axis shows coercive force (Oe). The conventional magnetic-recording medium shows the **** property shown in drawing 3 .

[0039] Drawing 4 is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer whose thickness is 0.8 nm like the 1st example of the above-mentioned record medium. A vertical axis shows residual magnetization (Gauss) among drawing 4 , and a horizontal axis shows coercive force (Oe). As drawing 4 also shows, as for a loop, it turns out that the shift was produced near the coercive force and antiferromagnetism combination has occurred. Drawing 5 is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer whose thickness is 1.4 nm. A vertical axis shows residual magnetization (emu) among drawing 5 , and a horizontal axis shows coercive force (Oe). The magnetization direction of two CoPt layers is parallel so that drawing 5 may also show.

[0040] Drawing 6 is drawing showing the magnetic properties within a field of two CoCrPt layers separated in Ru layer whose thickness is 0.8 nm like the 2nd example of the above. A vertical axis shows residual magnetization (emu/cc) among drawing 6 , and a horizontal axis shows coercive force (Oe). As drawing 6 also shows, as for a loop, it turns out that the shift was produced near the coercive force and antiferromagnetism combination has occurred.
[0041] From drawing 3 and drawing 4 , by preparing an exchange layer structure shows that anti-parallel combination can be obtained. Moreover, in order to obtain anti-parallel combination, the thickness of the nonmagnetic binder course 8 is preferably selected by the range of 0.4-1.0nm, so that drawing 5 may be understood by comparing with drawing 4 and drawing 6 .
[0042] Therefore, according to the 1st and 2nd examples of a magnetic-recording medium, effective particle volume can be increased by the switched connection through the nonmagnetic binder course between a magnetic layer and a ferromagnetic layer, without sacrificing resolution. That is, if it sees from particle volume so that the good medium of thermal stability can be realized, the thickness on the appearance of a magnetic layer can be made to increase. Moreover, since the reproduction output from a lower magnetic layer is negated, the thickness of an effective magnetic layer does not change. For this reason, although the thickness of the magnetic layer on appearance increases, since thickness of an effective magnetic layer is made thinly, without changing, the high resolution which is not obtained can be obtained by the thick medium. Consequently, the magnetic-recording medium which the medium noise was reduced and improved can be obtained.
[0043] Next, one example of magnetic storage which becomes this invention is explained with drawing 7 and drawing 8 . Drawing 7 is the cross section showing the important section of one example of magnetic storage, and drawing 8 is the plan showing the important section of one example of magnetic storage.
[0044] As shown in drawing 7 and drawing 8 , magnetic storage consists of profile housing 13. In housing 13, a motor 14, a hub 15, two or more magnetic-recording media 16, two or more record reproducing heads 17, two or more suspensions 18, two or more arms 19, and the actuator unit 20 are formed. The magnetic-recording medium 16 is attached in the hub 15 rotated by the motor 14. The record reproducing head 17 consists of the reproducing heads, such as an MR head and a GMR head, and recording heads, such as an inductive head. Each record reproducing head 17 is attached at the nose of cam of the corresponding arm 19 through the suspension 18. An arm 19 is driven by the actuator unit 20. The basic composition of this magnetic storage itself is common knowledge, and the detailed explanation is omitted on these specifications.
[0045] this example of magnetic storage has the feature in the magnetic-recording medium 16. Each magnetic-recording medium 16 has the structure of the 1st example of the above-mentioned magnetic-recording medium explained with drawing 1 and drawing 2 , or the 2nd example, or the structure of the 3rd example of the magnetic-recording medium later mentioned with drawing 9 or subsequent ones. Of course, the number of the magnetic-recording media 16 may not be limited to three sheets, but at least one sheet may be two sheets or four sheets or more.
[0046] The basic composition of magnetic storage is not limited to what is shown in drawing 7 and drawing 8 . Moreover, the magnetic-recording medium used by this invention is not limited to a magnetic disk.
[0047] By the way, in the magnetic-recording medium which has an exchange layer structure like the 1st example shown in drawing 1 , when Ru is used for the nonmagnetic binder course 8 and a CoCr system alloy is used for a magnetic layer 9, both these layers 8 and 9 have hcp structure. In order to make high both coercive force of a magnetic-recording medium, and resolution, it is desirable for the c axis of hcp structure to be parallel to the front face of a substrate 1. Since the ferromagnetic layer 7 grows epitaxially on the interlayer 6 who did orientation to the field which consists of an alloy of hcp structure (002) when a CoCr system alloy is used for the ferromagnetic layer 7, the stacking tendency within a field of the c axis of the ferromagnetic layer 7 is good.
[0048] On the other hand, although Ru used for the nonmagnetic binder course 8 has hcp structure like a CoCr system alloy, the lattice constant of Ru is latus about about 5% compared with the lattice constant

of a CoCr system alloy. For this reason, between the ferromagnetic layer 7 and the nonmagnetic binder course 8 or between the nonmagnetic binder course 8 and a magnetic layer 9, since epitaxial growth is a grid inequality, it may be prevented a little. Thus, if epitaxial growth is checked a little for a grid inequality, the coercive force of a magnetic-recording medium will decline, or the stacking tendency within a field of the c axis of a CoCr system alloy will become unstable.
[0049] then -- while improving epitaxial growth between Ru and a CoCr system alloy and improving the stacking tendency within a field of increase of the coercive force of a magnetic-recording medium, and the c axis of a CoCr system alloy -- the Lord of a magnetic-recording medium -- record -- resolution -- the example which makes a property improvable is explained below Drawing 9 is the cross section showing the important section of the 3rd example of the magnetic-recording medium which becomes this invention. It has the structure by which the laminating was carried out in this sequence as the nonmagnetic substrate 16, the seed layer 17, the ground layer 18 that consists of a Cr system alloy, the nonmagnetic interlayer 19, the ferromagnetic layer 20, the nonmagnetic binder course 21, a magnetic layer 22, a protective layer 23, and a lubricating layer 24 showed a magnetic-recording medium to drawing 9 .
[0050] The nonmagnetic substrate 16 consists of for example, an aluminum alloy or glass. The nonmagnetic substrate 16 does not need to be given even if texture processing is performed. The seed layer 17 consists of NiP formed by plating, when the nonmagnetic substrate 16 consists of an aluminum alloy. This NiP seed layer 17 does not need to be given even if texture processing is performed. Moreover, when the nonmagnetic substrate 16 consists of glass, the seed layer 17 consists of intermetallic-compound material which has B-2 structures, such as NiAl and FeAl.
[0051] The nonmagnetic interlayer 19 is formed in order to promote the orientation of epitaxial growth of a magnetic layer 22, reduction of grain-size distribution width of face, and the anisotropy shaft (c axis, easy axis) of a magnetic layer 22 along the field parallel to the recording surface of a magnetic-recording medium. This nonmagnetic interlayer 19 consists of an alloy which has the hcp structure of CoCr-M1 grade, and has the thickness selected by the range of about 1-5nm. Here, they are M1=B, Mo, Bn(s), Ta and W, or these alloys.
[0052] The ferromagnetic layer 20 consists of Co, nickel, Fe, Co system alloy, a nickel system alloy, a Fe system alloy, etc. That is, Co system alloy containing CoCrTa, CoCrPt, and CoCrPt-M2 can be used for the ferromagnetic layer 20. Here, they are M2=B, Mo, Nb(s), Ta and W, or these alloys. This ferromagnetic layer 20 has the thickness selected by the range of about 2-10nm.
[0053] The nonmagnetic binder course 21 consists of an alloy which has the hcp structure which becomes Ru-M3. Here, they are M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. The nonmagnetic binder course 21 has the thickness selected by the range of about 0.4-1.0nm, and has about 0.6-0.8nm thickness preferably. By selecting the thickness of the nonmagnetic binder course 21 to such a value, the magnetization direction of the ferromagnetic layer 20 and a magnetic layer 22 serves as anti-parallel mutually. Thus, the ferromagnetic layer 20 and the nonmagnetic binder course 19 constitute an exchange layer structure.
[0054] A magnetic layer 22 consists of a Co system alloy containing Co or CoCrTa, CoCrPt, and CoCrPt-M4. Here, they are M4=B, Mo, Nb(s), Ta and W, or these alloys. This magnetic layer 22 has the thickness selected by the range of about 5-30nm. Of course, it cannot be overemphasized that a magnetic layer 22 is not limited to the thing of a single layer structure, but you may have multilayer structure.
[0055] A protective layer 23 consists of C or DLC. Moreover, a lubricating layer 24 consists a magnetic-recording medium of organic substance lubricant for using magnetic transducers, such as for example, a spin valve head. A protective layer 23 and a lubricating layer 24 constitute the protective-layer structure of a magnetic-recording medium.
[0056] Like the above, the nonmagnetic binder course 21 consists of an alloy which becomes Ru-M3, and are M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. In this example, the addition of the element M3 added by Ru has a desirable composition range like a degree so that stable hcp structure may be maintained. The numeric value in the parenthesis following the alloying element M3 added by Ru shows atomic % (at%).

[0057] Ru-Co(0~50at%)
Ru-Cr(0~50at%)
Ru-Fe(0~60at%)
Ru-Ni(0~10at%)
Ru-Mn(0~50at%)
Drawing 10 is drawing showing the magnetization curve obtained when pure Ru is used for the nonmagnetic binder course 21 of the magnetic-recording medium shown in drawing 9 . A vertical axis shows Magnetization M (arbitrary unit) among this drawing, and a horizontal axis shows a magnetic field H (kOe). The magnetization curve shown in this drawing was measured with the oscillating sample type magnetometer, impressing a magnetic field in parallel with a sample side, i.e., the recording surface of a magnetic-recording medium. Since the field which ferromagnetic 20 and a magnetic layer 22 combine with anti-parallel exists, the vena contracta has arisen in the magnetization curve.
[0058] Moreover, the magnetization curve obtained when the alloy which becomes the nonmagnetic binder course 21 Ru-M3 is used was measured similarly. the nonmagnetic binder course 21 -- Ru-M3 -- the case where an alloy is used -- the case of drawing 10 -- the same -- ferromagnetism -- since the field which 20 and a magnetic layer 22 combine with anti-parallel existed, it was checked by the magnetization curve that the vena contracta arises
[0059] In addition, in drawing 10 , in the 1st quadrant and the 4th quadrant, a part for the bay in the magnetization curve by the side of a high magnetic field is extrapolated on a magnetic field shaft, and an intersection with a magnetic field shaft is defined as coercive force Hc/within field/from the vena contracta.
[0060] Drawing 11 is drawing showing the magnetization curve measured with the perpendicular car (Kerr) looper, impressing a magnetic field perpendicularly to a sample side to the magnetic-recording medium which measured the data of drawing 10 . A vertical axis shows car rotation (degree) among drawing 11 , and a horizontal axis shows a perpendicular magnetic field (Oe). Perpendicular coercive force Hc** shows the definition to drawing 11 .
[0061] the grade of the stacking tendency within a field of the easy axis of a magnetic layer 22 -- (Hc**)/(Hc//) -- a ratio can estimate this ratio (Hc**) -- it is shown that the stacking tendency within a field of a magnetic layer 22 is so good that / (Hc//) is small
[0062] coercive force Hc/[at the time of using various material for the nonmagnetic binder course 21] within field/, and a ratio (Hc**) -- the measurement result of / (Hc//) is shown below In addition, the relative value at the time of setting the coercive force Hc within a field at the time of using pure Ru for the nonmagnetic binder course 21//to 1 shows the coercive force Hc within a field//to various material.
Nonmagnetic binder course 21 Hc//(relative value) (Hc**) /(Hc//)
Ru 1 0.33Ru-Co(20at%) 1.10 0.23Ru-Cr(20at%) 1.05 0.25Ru-Fe(20at%) 1.07 0.28Ru-Mn(20at%) 0.96 0.30Ru-Ni(10at%) [0.94] 0.30 -- the case where pure Ru is used in this way even when which alloy of Ru-M3 is used for the nonmagnetic binder course 21 according to this example -- comparing -- a ratio (Hc**) -- the improvement was checked by the value of / (Hc//) the improvement of such a stacking tendency within a field of a magnetic layer 22 -- record -- it was also checked that resolution improves about 1.5 to 2.5%
[0063] Moreover, the interval of the field (002) of the hcp structure of Ru used for the nonmagnetic binder course 21 is adding an element M3 to Ru like the above, even if it has usually produced about a maximum of 5% of grid mismatching about 8% in the ferromagnetic layer 20 and magnetic layer 22 which are located up and down, and the case of being the worst, and it was checked about 6% or less in grid mismatching that it can decrease to 2% or less preferably. Furthermore, as an element M3 which can be added to Ru, although Above Co, Cr, Fe, nickel, and Mn or these alloys are desirable, it is not limited to these, for example, grid mismatching may be adjusted using Ir, Mo, Nb, Pt, Rh, Ta, Ti, V, W, or these alloys.
[0064] In addition, this example cannot be overemphasized by that it can apply also like the composition of the 2nd example of the above-mentioned magnetic-recording medium.
[0065] As mentioned above, although the example explained this invention, this invention is not limited

to the above-mentioned example, and it cannot be overemphasized that various deformation and improvement are possible.

[0066]

[Effect of the Invention] while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium and magnetic storage which resolution can improve are realizable

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[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the magnetic-recording medium and magnetic storage which started a magnetic-recording medium and magnetic storage, especially were suitable for high-density record.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The recording density of level magnetic-recording media, such as a magnetic disk, increased remarkably by development of reduction of a medium noise, a magnetoresistance-effect type head, and a spin valve head. A typical magnetic-recording medium has the structure where the laminating of a substrate, a ground layer, a magnetic layer, and the protective layer was carried out in this sequence. A ground layer consists of Cr or a Cr system alloy, and a magnetic layer consists of a Co system alloy.
[0003] The various proposals of the method of reducing a medium noise are made until now. For example, Okamoto et al., "Rigid Disk Medium For 5Gbit/in2 Recording", AB-3, Intermag '96 Decreasing the grain size and the size distribution of a magnetic layer is proposed by Digest by decreasing the thickness of a magnetic layer using the suitable ground layer which consists of CrMo. Moreover, in U.S. Pat. No. 5,693,426, using the ground layer which consists of NiAl is proposed. Furthermore, Hosoe et al. "Experimental Study of Thermal Decay inHigh-Density Magnetic Recording Media" IEEE Trans. Magn. Vol.33 In 1528 (1997), using the ground layer which consists of CrTi is proposed. The orientation within a field of a magnetic layer is urged to the ground layer like the above, and it makes the thermal stability of residual magnetization and a bit increase. Decreasing the thickness of a magnetic layer, making resolution high or decreasing the changes width of face between the written-in bits is also proposed. Furthermore, Cr segregation of the magnetic layer which consists of a CoCr system alloy is promoted, and decreasing the switched connection between particles is also proposed.
[0004] However, the written-in bit becomes instability according to the demagnetizing field and thermal activation which increase according to linear density as the particle of a magnetic layer becomes small and is isolated magnetic more mutually. Lu et al. "Thermal Instability at 10 Gbit/in2 Magnetic Recording" IEEE Trans. Magn. Vol.30 At 4230 (1994), it is a micro magnetic simulation. By the medium which had the switched connection of each particle of the ratio which a diameter becomes Ku V/kB T-60 in a 400kfci bit by 10nm suppressed, it is announced that it is easy to receive large thermal decay. Here, it is Ku. The constant of a magnetic anisotropy and V are the balancer product of a magnetic particle, and kB. A Boltzmann's constant and T show temperature. In addition, the ratio which becomes Ku V/kB T is also called thermal stability coefficient.
[0005] Abarra et al. "Thermal Stability of Narrow Track Bits in a 5 Gbit/in2Medium" IEEE Trans. Magn. In Vol.33 and 2995 (1997) It is 5Gbit/in2 to stabilize the bit in which existence of the exchange interaction between particles was written. MFM (force microscope between MAG) analysis of the 200kfci bit which annealed the CoCrPtTa/CrMo medium. It is reported. However, 20Gbit/in2 In the above recording density, suppression of the magnetic combination between the further particles becomes indispensable.
[0006] The proper solution over this was making the magnetic anisotropy of a magnetic layer increase. However, in order to make the magnetic anisotropy of a magnetic layer increase, a big load will be applied to the write-in magnetic field of a head.
[0007] moreover Thermally the coercive force of an unstable magnetic-recording medium helium et al.,

"High Speed Switching in Magnetic Recording Media" J. Magn. Magn. Mater. Vol.155 In 6 (1996) About a magnetic tape medium J. H. Richter "Dynamic Coercivity Effects in Thin Film Media" IEEE Trans.Magn. Vol.34 In 1540 (1997) According to reduction of switch time, it increases rapidly as the magnetic-disk medium is reported. For this reason, a bad influence will arise at data speed. That is, the magnetic field strength of a head required to be able to write data in a magnetic layer how much quickly, or reverse magnetization of a magnetic particle increases rapidly according to reduction of switch time.
[0008] On the other hand, the method to which the rate of orientation of a magnetic layer is made to increase is also proposed by performing suitable texture processing for the substrate under a magnetic layer as other methods of raising thermal stability. For example, Akimoto under issue et al. "MagneticRelaxation in Thin Film Media as a Function of Orientation" J. Magn. Magn. Mater. (1999) It is efficiency Ku·V/kB by the micro magnetic simulation. It is reported that a T value increases by the slight increase in the rate of orientation. Consequently, Abarra et al. "TheEffect of Orientation Ratio - the Dynamic Coercivity of Media for >15Gbit/in2 Recording" EB-02 Intermag The time dependency of the coercive force which improves the over-writing performance of a magnetic-recording medium can be weakened more as reported in '99 and Korea.
[0009] Furthermore, the keeper magnetic-recording medium for improving thermal stability is also proposed. A keeper layer consists of a soft-magnetism layer parallel to a magnetic layer. This soft-magnetism layer is arranged on a magnetic layer or in the bottom. In many cases, Cr MAG insulating layer is prepared between a soft-magnetism layer and a magnetic layer. A soft-magnetism layer decreases the demagnetizing field of the bit written in the magnetic layer. However, the purpose of decoupling of the particle of a magnetic layer is no longer attained by combination of a soft-magnetism layer which carries out switched connection to a magnetic-recording layer continuously. Consequently, a medium noise increases.

[Translation done.]

* NOTICES *

EFFECT OF THE INVENTION

[Effect of the Invention] while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium and magnetic storage which resolution can improve are realizable

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[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] What has various methods of improving thermal stability and reducing a medium noise is proposed. However, by the method proposed, the thermal stability of the written-in bit could not be improved sharply, but, for this reason, decreasing a medium noise sharply had the problem of being difficult. Furthermore, there was also a problem of having a bad influence on the performance of a magnetic-recording medium for the cure for reducing a medium noise depending on the proposal method.
[0011] Specifically, in order to obtain the high magnetic-recording medium of thermal stability, it is (i) magnetic-anisotropy constant Ku. The (ii) temperature T to which it is made to increase is decreased, or the cure of making the particle volume V of a magnetic layer (iii) increase etc. can be considered. However, as a cure (i), coercive force will increase and it will become more difficult to write information in a magnetic layer. On the other hand, considering that operating temperature, such as a disk drive, may exceed 60 degrees C, the cure (ii) is un-practical. Furthermore, a cure (iii) will make a medium noise increase like the above. Moreover, although also making the thickness of a magnetic layer increase is considered instead of a cure (iii), resolution will fall by this method. then -- while being able to perform reliable high-density record, without this invention's improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- it aims at offering the magnetic-recording medium and magnetic storage which resolution can improve

[Translation done.]

MEANS

[Means for Solving the Problem] The above-mentioned technical problem is equipped with at least one exchange layer structure and the magnetic layer prepared on this exchange layer structure. this exchange layer structure It consists of a ferromagnetic layer and a nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer, and the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually. this nonmagnetic binder course It consists of an alloy with which the element or the alloy M3 was added and which becomes Ru-M3, and is attained by the magnetic-recording medium characterized by addition of M3 adjusting the grid mismatching of this nonmagnetic binder course, this magnetic layer of the upper and lower sides, and this ferromagnetic layer to about 6% or less. while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium which resolution can improve is realizable

[0013] The above-mentioned technical problem is equipped with at least one exchange layer structure and the magnetic layer prepared on this exchange layer structure. this exchange layer structure It consists of a ferromagnetic layer and a nonmagnetic binder course which is on this ferromagnetic layer and was prepared in the bottom of this magnetic layer, and the magnetization directions of this ferromagnetic layer and this magnetic layer are anti-parallel mutually. this nonmagnetic binder course It consists of an alloy which becomes Ru-M3 and is attained by the magnetic-recording medium characterized by the bird clapper from M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. while being able to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic-recording medium which resolution can improve is realizable

[0014] the above M3 -- the addition to Ru of an element -- the case of Co -- 50at(s)% -- in Cr, in less than [50at%] and Fe, it may be hereafter selected [in the case of less than / 60at% / and nickel] by less than [50at%] in the case of less than [10at%] and Mn

[0015] The aforementioned nonmagnetic binder course is good also as composition which has the thickness selected within the limits of 0.4-1.0nm.

[0016] The aforementioned ferromagnetic layer may consist of material chosen from the group which consists of Co, nickel, Fe, nickel system alloy, Fe system alloy and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M2, and may be M2=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.

[0017] The aforementioned magnetic layer may consist of material chosen from the group which consists of Co and CoCrTa, CoCrPt, and a Co system alloy containing CoCrPt-M4, and may be M4=B, Mo, Nb(s), Ta, W and Cu(s), or these alloys.

[0018] The magnetic storage equipped with at least one magnetic-recording medium of one of the above-mentioned composition can also attain the above-mentioned technical problem. while being able

to perform reliable high-density record according to this invention, without improving the thermal stability of the written-in bit, reducing a medium noise, and having a bad influence on the performance of a magnetic-recording medium -- especially -- the improvement in the stacking tendency within a field of a magnetic layer -- record -- the magnetic storage which resolution can improve is realizable
[0019]
[Embodiments of the Invention] Hereafter, the example of this invention is explained with a drawing.

[Translation done.]

EXAMPLE

[Example] First, the principle of operation of this invention is explained.
[0021] Two or more layers which have the magnetization structure which is anti-parallel mutually are used for this invention. For example S. S.P. Parkin "Systematic Variation of the Strength and Oscillation Period of Indirect Magnetic Exchange Coupling though the 3d 4d and 5d Transition Metals" Phys. Rev. Lett. Vol.67 In 3598 (1991) Magnetic transition metals, such as Co, Fe, nickel, etc. which are combined with a magnetic layer through thin nonmagnetic interlayers, such as Ru and Rh, are explained. On the other hand, the spin bulb which uses the layer like the above as a pinning layer by which the laminating was carried out is proposed by the U.S. Pat. No. 5,701,223 official report for stabilization of a sensor.
[0022] When Ru or Rh layer prepared between two ferromagnetic layers has specific thickness, the magnetization direction of a ferromagnetic layer can be mutually made parallel or anti-parallel. For example, the effective grain size of a magnetic-recording medium can make it increase in the case of the structure where the magnetization direction consists of two ferromagnetic layers which are anti-parallel by mutually different thickness, without having substantial influence on resolution. Although the signal amplitude reproduced from such a magnetic-recording medium decreases by magnetization of an opposite direction, it can negate the influence by one layer to this by preparing the layer of suitable thickness and the magnetization direction in the bottom of laminating magnetic layer structure further. Consequently, the signal amplitude reproduced from a magnetic-recording medium can be increased, and effective particle volume can be increased. Therefore, the written-in high bit of thermal stability is realizable.
[0023] this invention raises the thermal stability of the written-in bit by carrying out switched connection of the magnetic layer in the magnetization direction contrary to other ferromagnetic layers, or using laminating ferrimagnetism structure. A ferromagnetic layer or laminating ferrimagnetism structure consists of a magnetic layer which consists of a particle exchanged - decoupled. That is, in order that this invention may raise the performance of the thermal stability of a magnetic-recording medium, an exchange pinning ferromagnetism layer or ferrimagnetism multilayer structure is used.
[0024] Drawing 1 is the cross section showing the important section of the 1st example of the magnetic-recording medium which becomes this invention. It has the structure by which the laminating was carried out in this sequence as the nonmagnetic substrate 1, the 1st seed layer 2, the NiP layer 3, the 2nd seed layer 4, the ground layer 5, the nonmagnetic interlayer 6, the ferromagnetic layer 7, the nonmagnetic binder course 8, a magnetic layer 9, a protective layer 10, and a lubricating layer 11 showed a magnetic-recording medium to drawing 1 .
[0025] For example, the nonmagnetic substrate 1 consists of aluminum, an aluminum alloy, or glass. This nonmagnetic substrate 1 does not need to be given even if texture processing is performed. Especially the 1st seed layer 2 consists of NiP, when the nonmagnetic substrate 1 consists of glass. The NiP layer 3 does not need to be given even if texture processing or oxidation treatment is performed. The 2nd seed layer 4 is formed in order to make good orientation of the field (001) of the ground layer 5 at the time of using the alloy of B-2 structures, such as NiAl and FeAl, for the ground layer 5, or (112) a field. The 2nd seed layer 4 consists of the same suitable material as the 1st seed layer 2.

[0026] Along with the hoop direction of a disk, i.e., the direction where the truck on a disk extends, when a magnetic-recording medium is a magnetic disk, texture processing performed to the nonmagnetic substrate 1 or the NiP layer 3 is performed.
[0027] The nonmagnetic interlayer 6 is formed in order to promote the orientation of epitaxial growth of a magnetic layer 9, reduction of particle distribution width of face, and the anisotropy shaft (easy axis) of a magnetic layer 9 along the field parallel to the recording surface of a magnetic-recording medium. This nonmagnetic interlayer 6 consists of an alloy which has hcp structure, such as CoCr-M, and has the thickness selected by the range of 1-5nm. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys.
[0028] The ferromagnetic layer 7 consists of Co, nickel, Fe, Co system alloy, a nickel system alloy, a Fe system alloy, etc. That is, Co system alloy containing CoCrTa, CoCrPt, and CoCrPt-M can be used for the ferromagnetic layer 7. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys. This ferromagnetic layer 7 has the thickness selected by the range of 2-10nm. The nonmagnetic binder course 8 consists of Ru, Rh, Ir, Ru system alloy, a Rh system alloy, an Ir system alloy, etc. For example, this nonmagnetic binder course 8 has the thickness selected by the range of 0.4-1.0nm, and has about 0.6-0.8nm thickness preferably. By selecting the thickness of the nonmagnetic binder course 8 in such a range, the magnetization direction of the ferromagnetic layer 7 and a magnetic layer 9 serves as anti-parallel mutually. The ferromagnetic layer 7 and the nonmagnetic binder course 8 constitute an exchange layer structure.
[0029] A magnetic layer 9 consists of a Co system alloy containing Co or CoCrTa, CoCrPt, and CoCrPt-M etc. Here, they are M=B, Mo, Nb(s), Ta and W, or these alloys. A magnetic layer 9 has the thickness selected by the range of 5-30nm. Of course, a magnetic layer 9 cannot be overemphasized by that you may be the composition which is not limited to the thing of a single layer structure, but consists of multilayer structure.
[0030] A protective layer 10 consists of C. Moreover, a lubricating layer 11 consists of organic substance lubricant for using a magnetic-recording medium with magnetic transducers, such as for example, a spin valve head. A protective layer 10 and a lubricating layer 11 constitute the protective-layer structure on a magnetic-recording medium.
[0031] The layer structure prepared in the bottom of an exchange layer structure is not limited to what is shown in drawing 1 , of course. For example, the ground layer 5 may consist of Cr or a Cr system alloy, and may be formed in the thickness selected on the substrate 1 by the range of 5-40nm, and an exchange layer structure may prepare it on such a ground layer 5.
[0032] Next, the 2nd example of the magnetic-recording medium which becomes this invention is explained.
[0033] Drawing 2 is the cross section showing the important section of the 2nd example of the magnetic-recording medium which becomes this invention. The same sign is given to the same portion as drawing 1 among this drawing, and the explanation is omitted.
[0034] An exchange layer structure consists of two nonmagnetic binder courses 8 which constitute ferrimagnetism multilayer structure, 8-1 and two ferromagnetic layers 7, and 7-1 in the 2nd example of this magnetic-recording medium. Since it negates each other, without two nonmagnetic binder courses 8 and magnetization of 8-1 negating a part of magnetic layer 9 by using such structure, it becomes possible to increase effective magnetization and a signal. Consequently, the particle volume of a magnetic layer 9 and the thermal stability of magnetization increase effectively. As long as the orientation of the easy axis of a record layer is kept desirable, increase of efficiency particle volume can be aimed at according to the two-layer structure which consists of a pair of a ferromagnetic layer and a non-magnetic layer and which is added.
[0035] The ferromagnetic layer 7-1 consists of the same material as the ferromagnetic layer 7, and thickness is also selected by the same range as the ferromagnetic layer 7. Moreover, the nonmagnetic binder course 8-1 consists of the same material as the nonmagnetic binder course 8, and is selected by the range as the nonmagnetic binder course 8 also with the same thickness. Between the ferromagnetic layer 7 and 7-1, c axis meets field inboard substantially and a particle grows pillar-shaped.
[0036] In this example, the magnetic anisotropy of the ferromagnetic layer 7-1 is set up more strongly

than the magnetic anisotropy of the ferromagnetic layer 7. Similarly the magnetic anisotropy of the ferromagnetic layer 7-1 may be set up, even if stronger [than the magnetic anisotropy of a magnetic layer 9] and weak. In short, the magnetic anisotropy of the ferromagnetic layer 7 should be just weaker than the layer 9 of the upper and lower sides, and 7-1.

[0037] Moreover, the residual magnetization of the ferromagnetic layer 7 and the product of thickness are set up smaller than the residual magnetization of the ferromagnetic layer 7-1, and the product of thickness.

[0038] Drawing 3 is drawing showing the magnetic properties within a field of the single CoPt layer of 10nm of thickness formed on Si substrate. A vertical axis shows magnetization (emu) among drawing 3 , and a horizontal axis shows coercive force (Oe). The conventional magnetic-recording medium shows the **** property shown in drawing 3 .

[0039] Drawing 4 is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer whose thickness is 0.8 nm like the 1st example of the above-mentioned record medium. A vertical axis shows residual magnetization (Gauss) among drawing 4 , and a horizontal axis shows coercive force (Oe). As drawing 4 also shows, as for a loop, it turns out that the shift was produced near the coercive force and antiferromagnetism combination has occurred. Drawing 5 is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer whose thickness is 1.4 nm. A vertical axis shows residual magnetization (emu) among drawing 5 , and a horizontal axis shows coercive force (Oe). The magnetization direction of two CoPt layers is parallel so that drawing 5 may also show.

[0040] Drawing 6 is drawing showing the magnetic properties within a field of two CoCrPt layers separated in Ru layer whose thickness is 0.8 nm like the 2nd example of the above. A vertical axis shows residual magnetization (emu/cc) among drawing 6 , and a horizontal axis shows coercive force (Oe). As drawing 6 also shows, as for a loop, it turns out that the shift was produced near the coercive force and antiferromagnetism combination has occurred.

[0041] From drawing 3 and drawing 4 , by preparing an exchange layer structure shows that anti-parallel combination can be obtained. Moreover, in order to obtain anti-parallel combination, the thickness of the nonmagnetic binder course 8 is preferably selected by the range of 0.4-1.0nm, so that drawing 5 may be understood by comparing with drawing 4 and drawing 6 .

[0042] Therefore, according to the 1st and 2nd examples of a magnetic-recording medium, effective particle volume can be increased by the switched connection through the nonmagnetic binder course between a magnetic layer and a ferromagnetic layer, without sacrificing resolution. That is, if it sees from particle volume so that the good medium of thermal stability can be realized, the thickness on the appearance of a magnetic layer can be made to increase. Moreover, since the reproduction output from a lower magnetic layer is negated, the thickness of an effective magnetic layer does not change. For this reason, although the thickness of the magnetic layer on appearance increases, since thickness of an effective magnetic layer is made thinly, without changing, the high resolution which is not obtained can be obtained by the thick medium. Consequently, the magnetic-recording medium which the medium noise was reduced and improved can be obtained.

[0043] Next, one example of magnetic storage which becomes this invention is explained with drawing 7 and drawing 8 . Drawing 7 is the cross section showing the important section of one example of magnetic storage, and drawing 8 is the plan showing the important section of one example of magnetic storage.

[0044] As shown in drawing 7 and drawing 8 , magnetic storage consists of profile housing 13. In housing 13, a motor 14, a hub 15, two or more magnetic-recording media 16, two or more record reproducing heads 17, two or more suspensions 18, two or more arms 19, and the actuator unit 20 are formed. The magnetic-recording medium 16 is attached in the hub 15 rotated by the motor 14. The record reproducing head 17 consists of the reproducing heads, such as an MR head and a GMR head, and recording heads, such as an inductive head. Each record reproducing head 17 is attached at the nose of cam of the corresponding arm 19 through the suspension 18. An arm 19 is driven by the actuator unit 20. The basic composition of this magnetic storage itself is common knowledge, and the detailed

explanation is omitted on these specifications.
[0045] this example of magnetic storage has the feature in the magnetic-recording medium 16. Each magnetic-recording medium 16 has the structure of the 1st example of the above-mentioned magnetic-recording medium explained with drawing 1 and drawing 2 , or the 2nd example, or the structure of the 3rd example of the magnetic-recording medium later mentioned with drawing 9 or subsequent ones. Of course, the number of the magnetic-recording media 16 may not be limited to three sheets, but at least one sheet may be two sheets or four sheets or more.
[0046] The basic composition of magnetic storage is not limited to what is shown in drawing 7 and drawing 8 . Moreover, the magnetic-recording medium used by this invention is not limited to a magnetic disk.
[0047] By the way, in the magnetic-recording medium which has an exchange layer structure like the 1st example shown in drawing 1 , when Ru is used for the nonmagnetic binder course 8 and a CoCr system alloy is used for a magnetic layer 9, both these layers 8 and 9 have hcp structure. In order to make high both coercive force of a magnetic-recording medium, and resolution, it is desirable for the c axis of hcp structure to be parallel to the front face of a substrate 1. Since the ferromagnetic layer 7 grows epitaxially on the interlayer 6 who did orientation to the field which consists of an alloy of hcp structure (002) when a CoCr system alloy is used for the ferromagnetic layer 7, the stacking tendency within a field of the c axis of the ferromagnetic layer 7 is good.
[0048] On the other hand, although Ru used for the nonmagnetic binder course 8 has hcp structure like a CoCr system alloy, the lattice constant of Ru is latus about about 5% compared with the lattice constant of a CoCr system alloy. For this reason, between the ferromagnetic layer 7 and the nonmagnetic binder course 8 or between the nonmagnetic binder course 8 and a magnetic layer 9, since epitaxial growth is a grid inequality, it may be prevented a little. Thus, if epitaxial growth is checked a little for a grid inequality, the coercive force of a magnetic-recording medium will decline, or the stacking tendency within a field of the c axis of a CoCr system alloy will become unstable.
[0049] then -- while improving epitaxial growth between Ru and a CoCr system alloy and improving the stacking tendency within a field of increase of the coercive force of a magnetic-recording medium, and the c axis of a CoCr system alloy -- the Lord of a magnetic-recording medium -- record -- resolution -- the example which makes a property improvable is explained below Drawing 9 is the cross section showing the important section of the 3rd example of the magnetic-recording medium which becomes this invention. It has the structure by which the laminating was carried out in this sequence as the nonmagnetic substrate 16, the seed layer 17, the ground layer 18 that consists of a Cr system alloy, the nonmagnetic interlayer 19, the ferromagnetic layer 20, the nonmagnetic binder course 21, a magnetic layer 22, a protective layer 23, and a lubricating layer 24 showed a magnetic-recording medium to drawing 9 .
[0050] The nonmagnetic substrate 16 consists of for example, an aluminum alloy or glass. The nonmagnetic substrate 16 does not need to be given even if texture processing is performed. The seed layer 17 consists of NiP formed by plating, when the nonmagnetic substrate 16 consists of an aluminum alloy. This NiP seed layer 17 does not need to be given even if texture processing is performed. Moreover, when the nonmagnetic substrate 16 consists of glass, the seed layer 17 consists of intermetallic-compound material which has B-2 structures, such as NiAl and FeAl.
[0051] The nonmagnetic interlayer 19 is formed in order to promote the orientation of epitaxial growth of a magnetic layer 22, reduction of grain-size distribution width of face, and the anisotropy shaft (c axis, easy axis) of a magnetic layer 22 along the field parallel to the recording surface of a magnetic-recording medium. This nonmagnetic interlayer 19 consists of an alloy which has the hcp structure of CoCr-M1 grade, and has the thickness selected by the range of about 1-5nm. Here, they are M1=B, Mo, Bn(s), Ta and W, or these alloys.
[0052] The ferromagnetic layer 20 consists of Co, nickel, Fe, Co system alloy, a nickel system alloy, a Fe system alloy, etc. That is, Co system alloy containing CoCrTa, CoCrPt, and CoCrPt-M2 can be used for the ferromagnetic layer 20. Here, they are M2=B, Mo, Nb(s), Ta and W, or these alloys. This ferromagnetic layer 20 has the thickness selected by the range of about 2-10nm.

[0053] The nonmagnetic binder course 21 consists of an alloy which has the hcp structure which becomes Ru-M3. Here, they are M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. The nonmagnetic binder course 21 has the thickness selected by the range of about 0.4-1.0nm, and has about 0.6-0.8nm thickness preferably. By selecting the thickness of the nonmagnetic binder course 21 to such a value, the magnetization direction of the ferromagnetic layer 20 and a magnetic layer 22 serves as anti-parallel mutually. Thus, the ferromagnetic layer 20 and the nonmagnetic binder course 19 constitute an exchange layer structure.
[0054] A magnetic layer 22 consists of a Co system alloy containing Co or CoCrTa, CoCrPt, and CoCrPt-M4. Here, they are M4=B, Mo, Nb(s), Ta and W, or these alloys. This magnetic layer 22 has the thickness selected by the range of about 5-30nm. Of course, it cannot be overemphasized that a magnetic layer 22 is not limited to the thing of a single layer structure, but you may have multilayer structure.
[0055] A protective layer 23 consists of C or DLC. Moreover, a lubricating layer 24 consists a magnetic-recording medium of organic substance lubricant for using magnetic transducers, such as for example, a spin valve head. A protective layer 23 and a lubricating layer 24 constitute the protective-layer structure of a magnetic-recording medium.
[0056] Like the above, the nonmagnetic binder course 21 consists of an alloy which becomes Ru-M3, and are M3=Co, Cr(s), Fe(s), nickel and Mn, or these alloys. In this example, the addition of the element M3 added by Ru has a desirable composition range like a degree so that stable hcp structure may be maintained. The numeric value in the parenthesis following the alloying element M3 added by Ru shows atomic % (at%).
[0057] Ru-Co(0~50at%)
Ru-Cr(0~50at%)
Ru-Fe(0~60at%)
Ru-Ni(0~10at%)
Ru-Mn(0~50at%)
Drawing 10 is drawing showing the magnetization curve obtained when pure Ru is used for the nonmagnetic binder course 21 of the magnetic-recording medium shown in drawing 9 . A vertical axis shows Magnetization M (arbitrary unit) among this drawing, and a horizontal axis shows a magnetic field H (kOe). The magnetization curve shown in this drawing was measured with the oscillating sample type magnetometer, impressing a magnetic field in parallel with a sample side, i.e., the recording surface of a magnetic-recording medium. Since the field which ferromagnetic 20 and a magnetic layer 22 combine with anti-parallel exists, the vena contracta has arisen in the magnetization curve.
[0058] Moreover, the magnetization curve obtained when the alloy which becomes the nonmagnetic binder course 21 Ru-M3 is used was measured similarly. the nonmagnetic binder course 21 -- Ru-M3 -- the case where an alloy is used -- the case of drawing 10 -- the same -- ferromagnetism -- since the field which 20 and a magnetic layer 22 combine with anti-parallel existed, it was checked by the magnetization curve that the vena contracta arises
[0059] In addition, in drawing 10 , in the 1st quadrant and the 4th quadrant, a part for the bay in the magnetization curve by the side of a high magnetic field is extrapolated on a magnetic field shaft, and an intersection with a magnetic field shaft is defined as coercive force Hc/within field/from the vena contracta.
[0060] Drawing 11 is drawing showing the magnetization curve measured with the perpendicular car (Kerr) looper, impressing a magnetic field perpendicularly to a sample side to the magnetic-recording medium which measured the data of drawing 10 . A vertical axis shows car rotation (degree) among drawing 11 , and a horizontal axis shows a perpendicular magnetic field (Oe). Perpendicular coercive force Hc** shows the definition to drawing 11 .
[0061] the grade of the stacking tendency within a field of the easy axis of a magnetic layer 22 -- (Hc**)/(Hc//) -- a ratio can estimate this ratio (Hc**) -- it is shown that the stacking tendency within a field of a magnetic layer 22 is so good that / (Hc//) is small
[0062] coercive force Hc/[at the time of using various material for the nonmagnetic binder course 21] within field/, and a ratio (Hc**) -- the measurement result of / (Hc//) is shown below In addition, the

relative value at the time of setting the coercive force Hc within a field at the time of using pure Ru for the nonmagnetic binder course 21//to 1 shows the coercive force Hc within a field//to various material.
Nonmagnetic binder course 21 Hc//(relative value) (Hc**) /(Hc//)
Ru 1 0.33Ru-Co(20at%) 1.10 0.23Ru-Cr(20at%) 1.05 0.25Ru-Fe(20at%) 1.07 0.28Ru-Mn(20at%) 0.96 0.30Ru-Ni(10at%) [0.94] 0.30 -- the case where pure Ru is used in this way even when which alloy of Ru-M3 is used for the nonmagnetic binder course 21 according to this example -- comparing -- a ratio (Hc**) -- the improvement was checked by the value of / (Hc//) the improvement of such a stacking tendency within a field of a magnetic layer 22 -- record -- it was also checked that resolution improves about 1.5 to 2.5%
[0063] Moreover, the interval of the field (002) of the hcp structure of Ru used for the nonmagnetic binder course 21 is adding an element M3 to Ru like the above, even if it has usually produced about a maximum of 5% of grid mismatching about 8% in the ferromagnetic layer 20 and magnetic layer 22 which are located up and down, and the case of being the worst, and it was checked about 6% or less in grid mismatching that it can decrease to 2% or less preferably. Furthermore, as an element M3 which can be added to Ru, although Above Co, Cr, Fe, nickel, and Mn or these alloys are desirable, it is not limited to these, for example, grid mismatching may be adjusted using Ir, Mo, Nb, Pt, Rh, Ta, Ti, V, W, or these alloys.
[0064] In addition, this example cannot be overemphasized by that it can apply also like the composition of the 2nd example of the above-mentioned magnetic-recording medium.
[0065] As mentioned above, although the example explained this invention, this invention is not limited to the above-mentioned example, and it cannot be overemphasized that various deformation and improvement are possible.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the cross section showing the important section of the 1st example of the magnetic-recording medium which becomes this invention.
[Drawing 2] It is the cross section showing the important section of the 2nd example of the magnetic-recording medium which becomes this invention.
[Drawing 3] It is drawing showing the magnetic properties within a field of the single CoPt layer of 10nm of thickness formed on Si substrate.
[Drawing 4] Thickness is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer which is 0.8 nm.
[Drawing 5] Thickness is drawing showing the magnetic properties within a field of two CoPt layers separated in Ru layer which is 1.4 nm.
[Drawing 6] Thickness is drawing showing the magnetic properties within a field of two CoCrPt layers separated in Ru layer which is 0.8 nm.
[Drawing 7] It is the cross section showing the important section of one example of magnetic storage which becomes this invention.
[Drawing 8] It is the plan showing the important section of one example of magnetic storage.
[Drawing 9] It is the cross section showing the important section of the 3rd example of the magnetic-recording medium which becomes this invention.
[Drawing 10] It is drawing showing the magnetization curve obtained when pure Ru is used for the nonmagnetic binder course of a magnetic-recording medium.
[Drawing 11] It is drawing showing the magnetization curve measured with the perpendicular car looper, impressing a magnetic field perpendicularly to a sample side.
[Description of Notations]
16 Substrate
17 Seed Layer
18 Ground Layer
19 Nonmagnetic Interlayer
20 Ferromagnetic Layer
21 Nonmagnetic Binder Course
22 Magnetic Layer
23 Protective Layer
24 Lubricating Layer

[Translation done.]

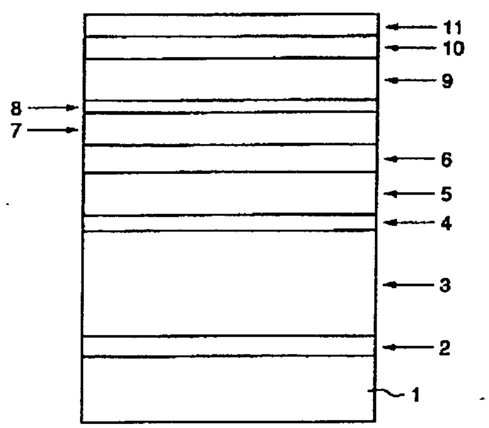
* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

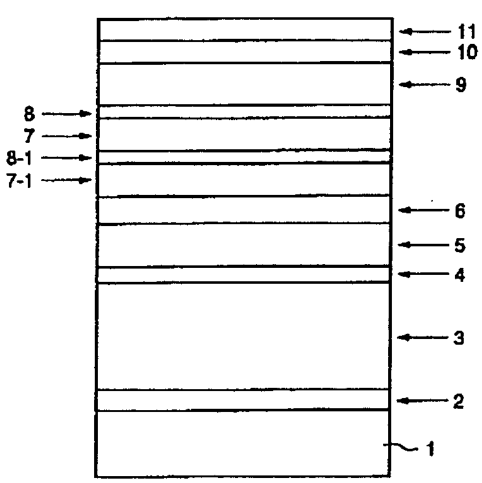
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]
本発明になる磁気記録媒体の第1実施例の要部を示す断面図

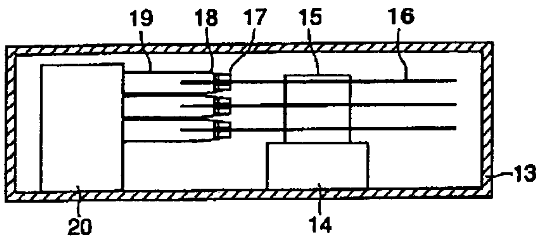


[Drawing 2]
本発明になる磁気記録媒体の第2実施例の要部を示す断面図

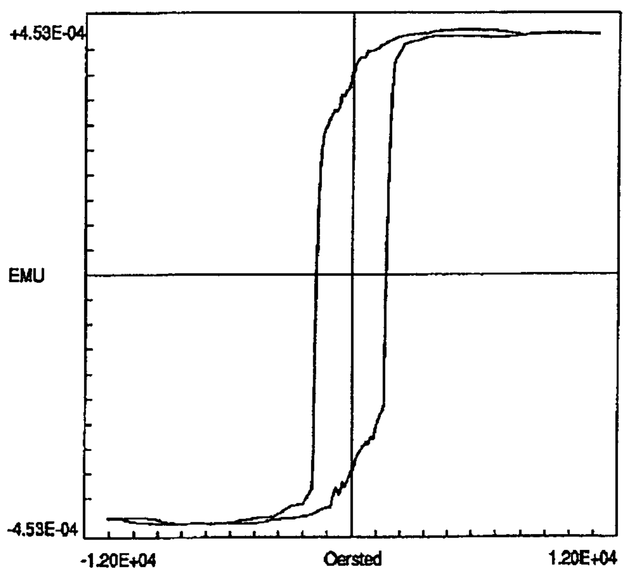


[Drawing 7]

本発明になる磁気記憶装置の一実施例の要部を示す断面図

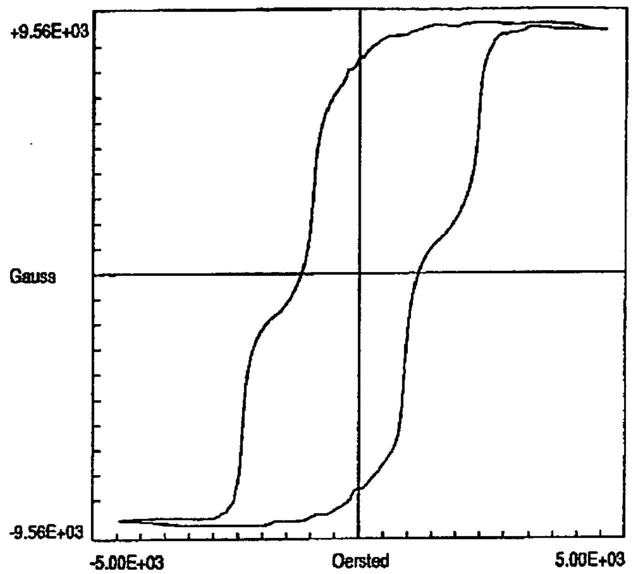


[Drawing 3]
Si基板上に形成された膜厚10nmの単一のCoPt層の面内磁気特性を示す図

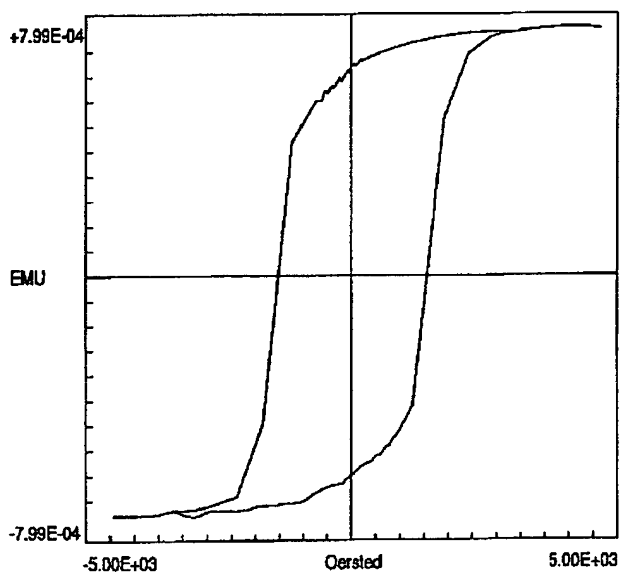


[Drawing 4]

膜厚が0.8nmのRu層で分離された2つのCoPt層の面内磁気特性を示す図

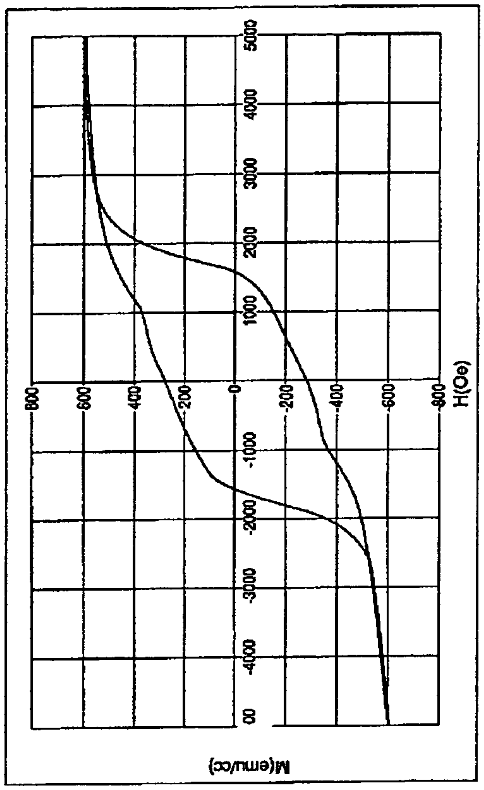


[Drawing 5]
膜厚が1.4nmのRu層で分離された2つのCoPt層の面内磁気特性を示す図

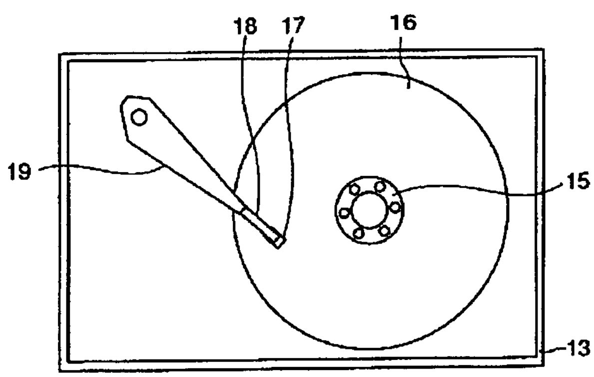


[Drawing 6]

膜厚が0.8nmのRu層で分離された2つのCoCrPt層の面内磁気特性を示す図

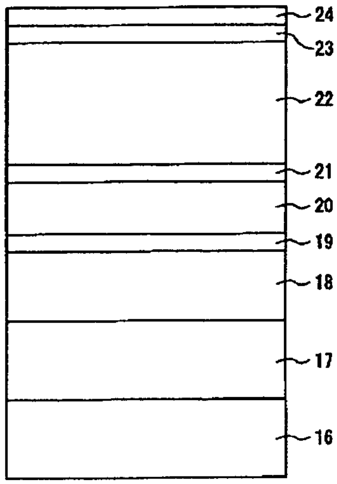


[Drawing 8]
磁気記憶装置の一実施例の要部を示す平面図



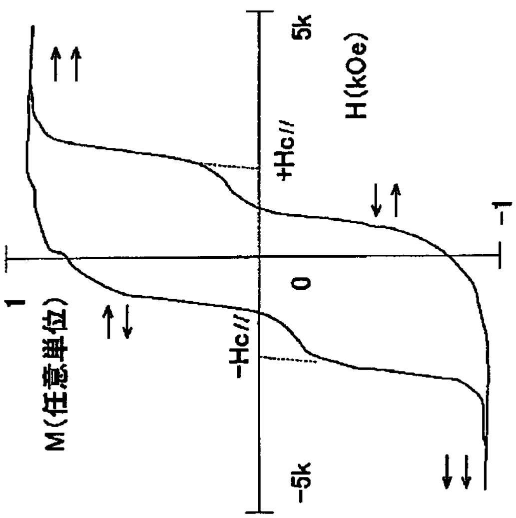
[Drawing 9]

本発明になる磁気記録媒体の第３実施例の要部を示す断面図



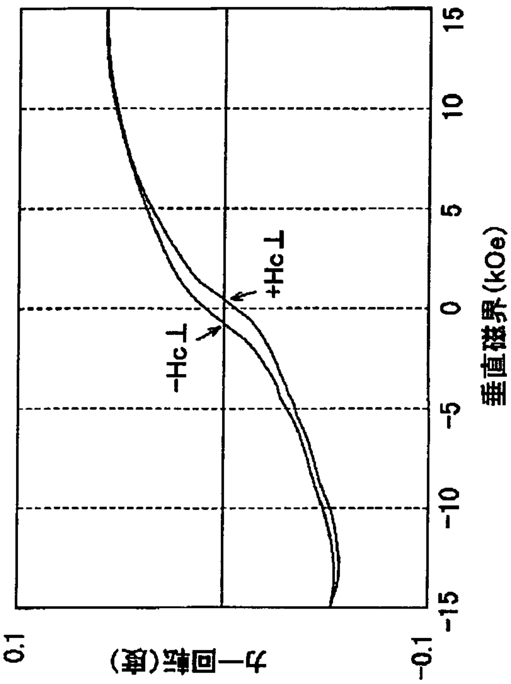
[Drawing 10]

磁気記録媒体の非磁性結合層に純Ｒｕを
用いた場合に得られる磁化曲線を示す図



[Drawing 11]

試料面に対して垂直方向に磁界を印加しながら、
垂直カールーパーにより測定した磁化曲線を示す図



[Translation done.]